Project title: "Loss of life, evacuation and emergency management – application of Dutch models to US case studies"

<u>First Interim report</u>

Approved for public release; Distribution unlimited **Date**: Nov 16, 2012

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Abstract:

The objective of this project is to investigate the application of Dutch models for Loss of life and evacuation analysis to US case studies. Within this first phase data has been collected for the first case study, the Natomas Basin, and runs with the Evacuaid model have been made. In addition, a plan for flood and loss of life simulations has been prepared for the second case study, New Orleans. The Dutch team will meet USACE experts from Nov 26 – 29 (2012) in Davis (CA) to discuss the next steps.

Appendices to this first interim report:

1. Evacuation analysis Natomas area, preliminary results
2. Project proposal flood simulations and risk to life analysis New Orleans

Nest steps / next phase (nov 15 – Jan 15, 2013):

- Nov 26 – 29, 2012: workshop in Davis (CA) to discuss the next steps
- Further analysis of evacuation and loss of life for the Natomas Basin
- Flood simulations and loss of life analysis for New Orleans
- Selection and initiation of third case study
- Reporting (second interim and final report)

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Appendix 1 : Evacuation analysis Natomas area, preliminary results

Introduction

This may presents an overview of the steps that have been taken so far in the Natomas evacuation project. The following topics are addressed:

- Population data
- Evacuation process

Population data

Population data are based on the Census Group Blocks 2010[1] of Sacramento County and Sutter County:

1. Sacramento: 53 group blocks (99,480 persons)
    a. Range:0 – 4652 persons per Group Block
    b. Median: 1707 persons, Average: 1877 persons
2. Sutter: 1 group block (1,000 persons)

In the evacuation calculation it is assumed that residents within a census group block evacuate from the centroid in the group block. Figure 1 presents an overview of the census group blocks in Natomas area. Inhabitants of Sutter County in Natomas are represented by only one group block. Figure 1 shows that the Sutter County census group block is partly located outside the Natomas area. This causes on overestimation of the true population in the Natomas area. Because population data on the level of Census Blocks is yet unavailable for 2010, the exact population overestimation is unclear. However, given that the Sutter County census group block represents 1,000 people, the maximum overestimation is less than 1% (1,000/ 100,480).

[1] Population: http://www.census.gov/geo/www/2010census/centerpop2010/blkgrp/bgcenters.html

Shapes: ftp://ftp2.census.gov/geo/pvs/tiger2010st/

memorandum

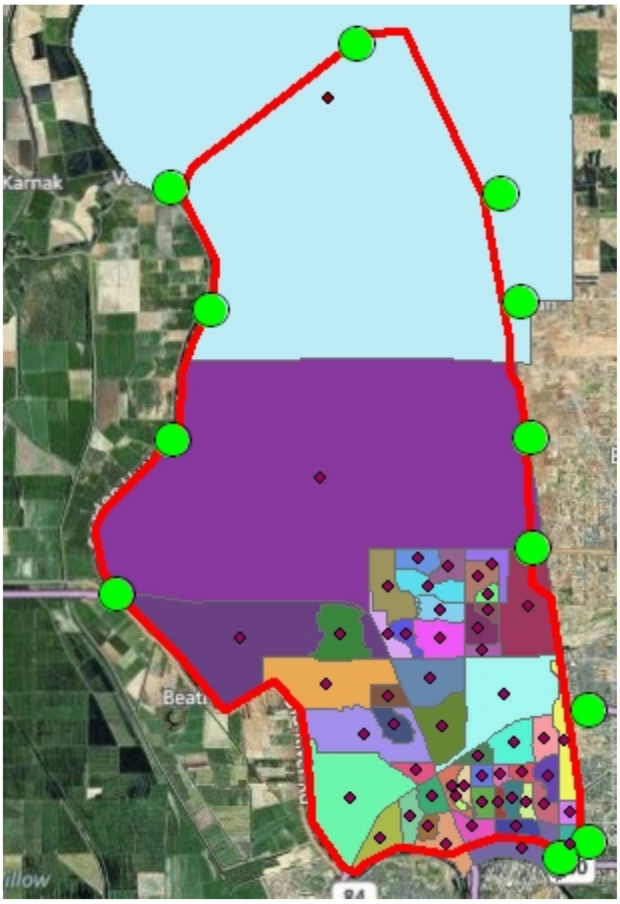

Figure 1: Census group blocks in Natomas area

Evacuation process

Two evacuation strategies

Authorities can choose between different types of evacuation, depending on the situation at hand. When a flood threat is detected several days ahead, authorities may decide that the whole Natomas area is to be evacuated. However, when time is limited or a flood occurs unexpected authorities may decide that people need to take shelter on a safe (high) location in their homes or in public buildings. Therefore, evacuation calculations were performed considering two different strategies:

1. Preventive horizontal evacuation: authorities advice the population to evacuate the Natomas area
2. Vertical evacuation: authorities advice the population to stay at home

The evacuation process comprises three steps:

- Departure: the time required to leave from home and arrive on the evacuation road network.
- Travel: travel time reflects the time period that a vehicle is on the evacuation road network until it reaches its destination.

- Exit: the destinations are the locations where people are considered to be safe. Vehicles that have reached a destination location have completed the evacuation.

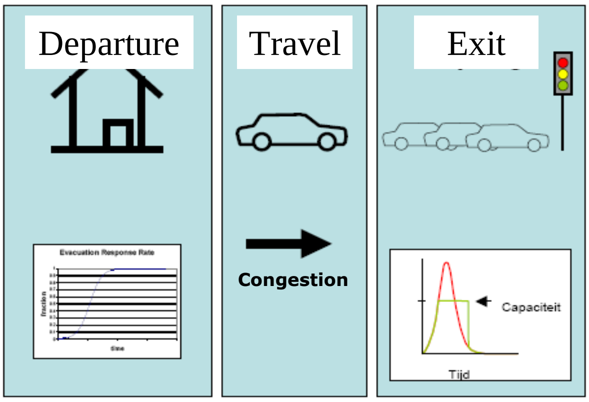

Figure 2: evacuation process

Departure

The departure process is the time that it takes for people to leave from their homes and arrive on the evacuation road network. Two departure curves are distinguished:

- Four hour departure curve
- Eight hour departure curve

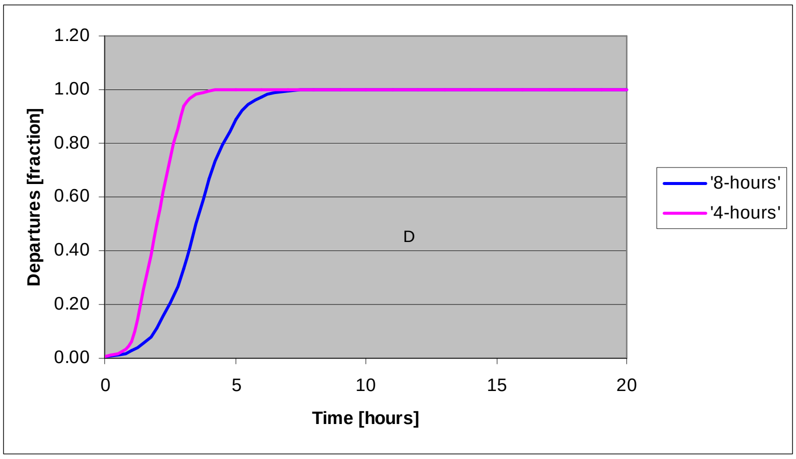

Figure 3: departure curves

Travel

The travel process reflects the time that vehicles are on the evacuation road network. To calculate evacuation times, three traffic distribution scenarios are distinguished:

1. Reference situation: The evacuees from the “origin zones” (the areas where they originate) are distributed equally over all possible exit points. This strategy approaches a situation in which no direction is given in the evacuation process. Crossing flows at crossroads are present. This situation brings about unhelpful circumstances that can be avoided by implementing better strategies.
2. Nearest exit (worst case): People leave at nearest exit. This strategy gives priority to the minimization of car kilometers. There will be no crossing flows at intersections so that the chance of queues and accidents at intersections will be reduced. However, the capacity of the network will not be used optimally.
3. Traffic management (best case): Exits are used proportionally to their capacity, crossing traffic flows at intersections are avoided and car-kilometers are minimized (giving proportional use of exits). In this way directed, convergent, non-crossing traffic flows to the exit points are realized.

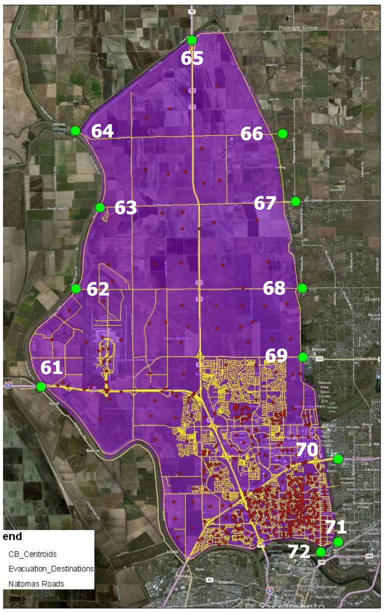

Figure 4: Natomas area and exit locations. Exits 62, 63 and 64 are located on the river levee

Centroid	FID	Street name	Free flow speed [mph]	Available Lanes	Capacity	
61	5461	I 5 NB	65	2	4600	2300 per lane
62	3098	W ELVERTA RD	50	1	1600	1600 per lane
63	4201	RIEGO RD	50	1	1600	
64	4185	GARDEN HWY	50	1	1500	
65	4221	HWY 99 NB	50	1	1500	
66	4196	SANKEY RD	50	1	1500	
67	4195	RIEGO RD	50	1	1600	

68	204	W ELVERTA RD	50	1	1600	
69	2909	W ELKHORN BLVD	50	1	1500	
70	2271	I 80 EB	65	3	6900	2300 per lane
71	2482	ARDEN GARDEN CONNECTOR	50	2	3200	1600 per lane
72	2078	NORTHGATE BLVD	50	1	1500	

Table 1: Road capacities

Results of evacuation calculations

The Evacuation Calculator (EC) was applied to calculate evacuation times. Evacuation calculations were performed in two steps. In the first step evacuation times were calculated for a reference situation, reflecting the ‘standard’ parameter settings for departure (departure curve), travel (PAE, speed, road capacities) and destinations (exit points). In the second step evacuation times were calculated for variations in the settings of five parameters (in total nine variations).

In total, the calculations resulted in 66 evacuation curves: 2 strategies (preventive, vertical) * 3 traffic scenarios (reference, nearest exit, traffic management) * (2 reference situations + 9 parameter variations).

Step 1: reference situation

Two reference situations were considered. In the first reference situation evacuation times were calculated considering all twelve exits (see Figure 4). In the second reference situation the exits 62, 63 and 64 were removed. These exits are located on the river levee and therefore cannot be considered as safe evacuation destinations.

The following parameter settings were applied to calculate evacuation times in the two reference situations:

1. Non-response:
   a. Preventive horizontal evacuation: 10% of the population stays at home in the Natomas area
   b. Vertical evacuation: 90% of the population stays at home in the Natomas area
2. Departure Curve (DC): after 4 hours all inhabitants have left their homes and started to evacuate (except for the proportion non-response)
3. PAE: on average there are 3 persons in one vehicle
4. Speed: vehicles travel with 12.5 mph
5. Out flow factor: 0.2, i.e., road capacities on the exit points are 20% of the free flow capacity

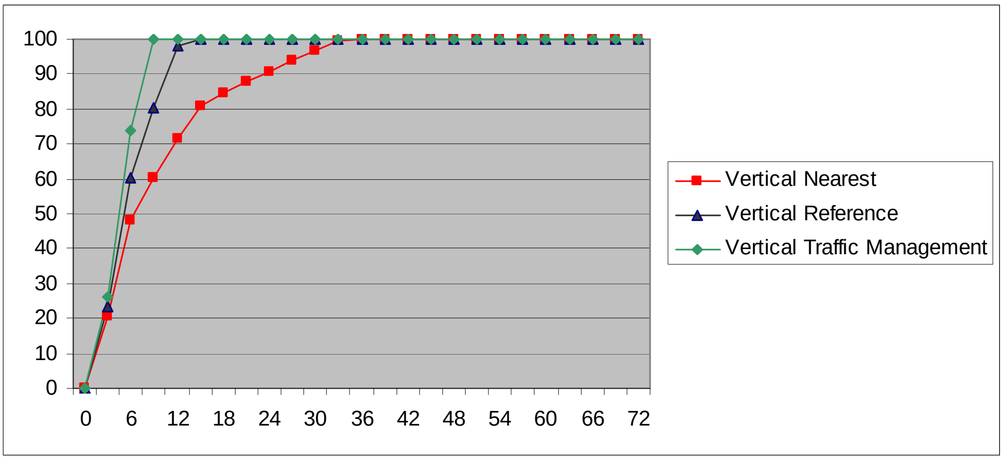

Figure 5 and Figure 6 show the results of the second reference situation.

Figure 5: evacuation curves for preventive horizontal evacuation (non-response 10%) in the second reference situation (without exits 62, 63 and 64).

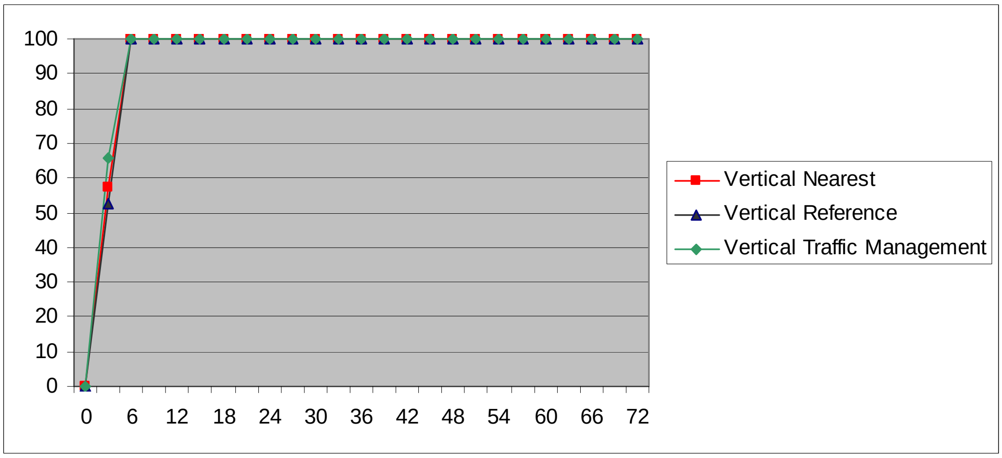

Figure 6: evacuation curves for vertical evacuation (non-response 90%) in the second reference situation (without exits 62, 63 and 64).

Step 2: evacuation times for variations in parameter settings

Varying the parameter settings for the departure curve, speed, average number of people in a vehicle, availability of evacuation exits and road capacities, provides insight in the range of evacuation times that results from either more pessimistic or more optimistic assumptions. The following parameter settings were applied to calculate the variations in evacuation times (nine variations):

1. Departure curve: 8 hrs departure curve
2. PAE:
    a. PAE: 2 persons per vehicle
    b. PAE: 4 persons per vehicle
3. Speed:
    a. Speed: 5 mph
    b. Speed: 20 mph
4. Unavailable exits:
    a. Most important exit unavailable (Nearest exit: without exit 69; Traffic management: without exit 70)
    b. Second most important exit unavailable (Nearest exit: without exit 70; Traffic management: without exit 61)
5. Outflow factor on the exit points (road capacity reduction factor):
    a. Out flow factor 0.1
    b. Out flow factor 0.3

Figure 7 and Figure 8 illustrate the results for the slower 8 hours departure curve.

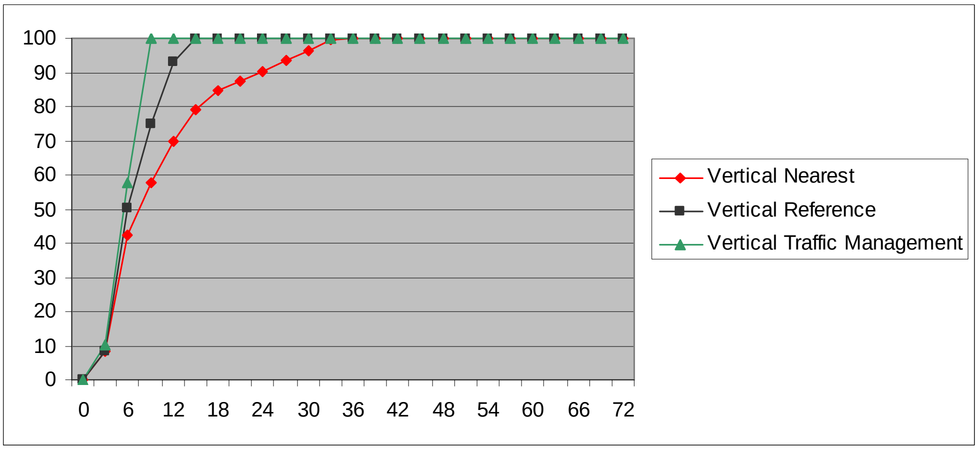

Figure 7: evacuation curves for preventive horizontal evacuation with slower departure curve (8 hrs).

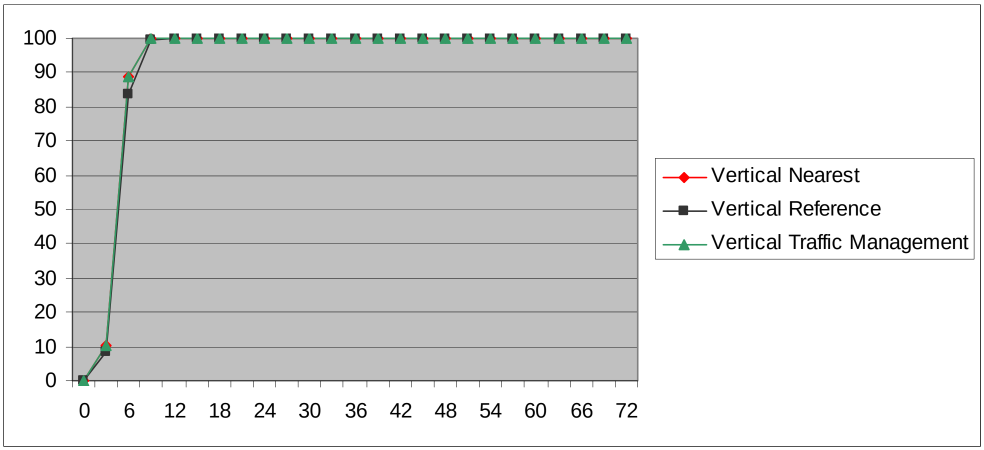

Figure 8: evacuation curves for vertical evacuation with slower departure curve (8 hrs).

Next Steps

- Results of the 66 evacuation curves are exported to EvacuAid.
- EvacuAid results (evacuation fractions) were applied in event trees resulting in expected values of evacuation fractions

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Appendix 2 : Project proposal flood simulations and risk to life analysis New Orleans

Date : 09th of November 2012

From : University of Technology

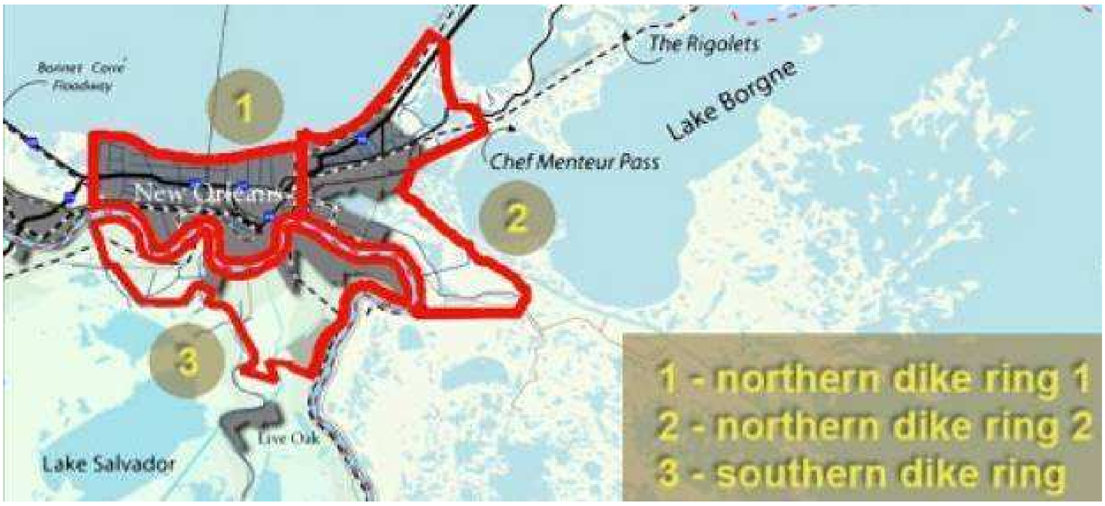
To : USACE

1 Introduction

Miller [2011] did research after the present risk to life due to flooding in the post-Katrina situation in New Orleans. Miller executed her research in cooperation with the University of Technology Delft and Royal Haskoning. This section explains what has been done in this Miller' study. Based on this recommendations will be given for a further approach to get insight in the present risk to life in New Orleans' post-Katrina situation.

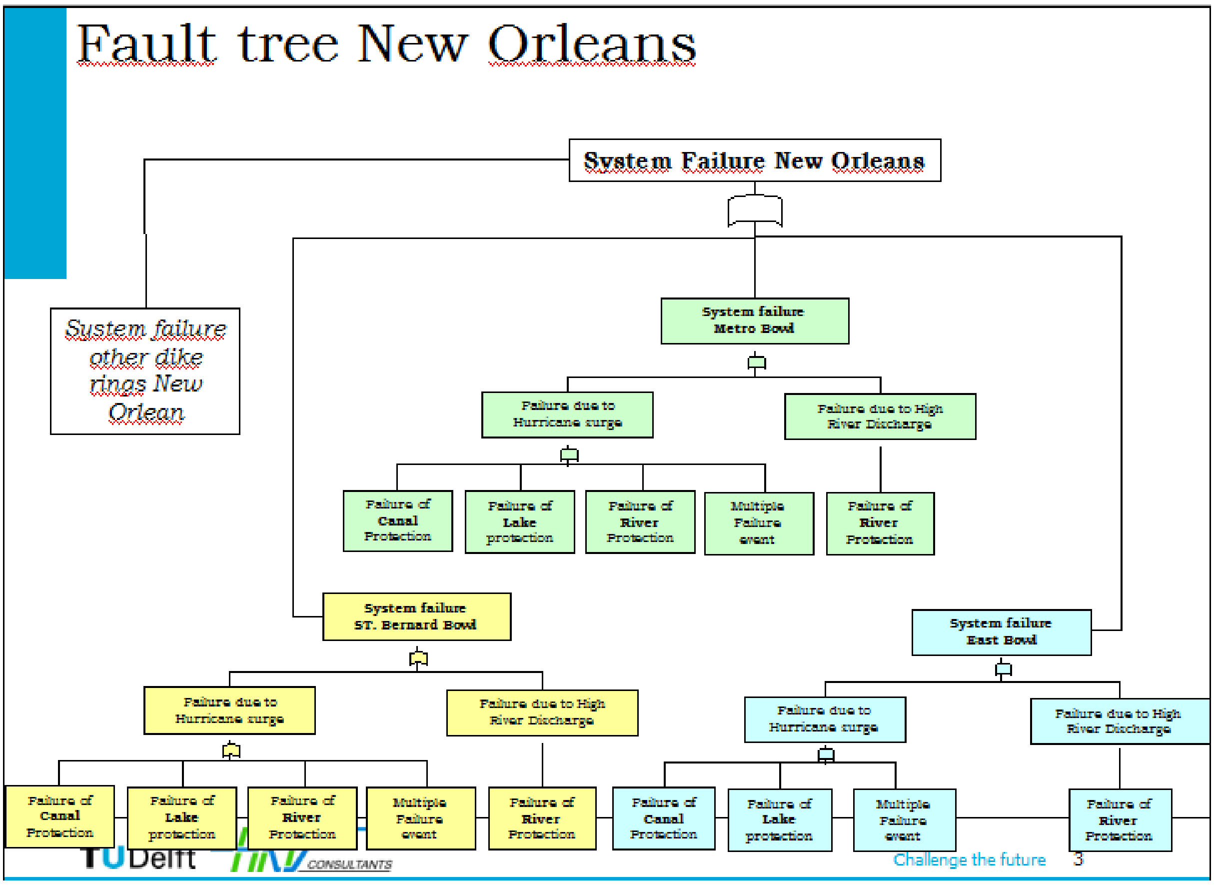
2 What's done?

The city of New Orleans is located along the Mississippi River and is bordered to the north by Lake Pontchartrain and to the east by Lake Borgne. Coastal wetlands separate New Orleans from the sea. The city of New Orleans is located in three separate dike rings (see figure below).



Risk analysis
It is recommended to do a full-integrated risk analysis for the greater city of New Orleans. An integrated risk analysis incorporates both the loss of life and the economic risk level. A risk to life analysis for the New Orleans Metro Bowl (area #1 in figure above) is done by Miller [2011]. For this area the risk to life for the post-Katrina situation is quantified in various metrics, as the individual risk and social risk.

Reliability analysis
The present protection level 1/100 per year.



Scenario	Dike ring	Location	Failure Mechanism	Individual / multiple breach
1	Metro Bowl	River Breach	High river discharge	Individual
2	Metro Bowl	River Breach	Storm surge	Individual
3	Metro Bowl	Lake Pontchartrain Breach at West End	Storm surge	Individual
4	Metro Bowl	Lake Pontchartrain Breach at St. John	Storm surge	Individual
5	Metro Bowl	IHNC Breach	Failure IHNC & MRCO/GIWW gate	Individual
6	East Bowl	Lake Pontchartrain Breach	Storm surge	Individual
7	East Bowl	IHNC Breach	Failure IHNC & MRCO/GIWW gate	Individual
8	East Bowl	Lake Borgne Breach	Storm surge	Individual
9	East Bowl	GIWW Breach	Failure MRGO/GIWW gate	Individual
10	St. Bernard Bowl	River Breach	High river discharge	Individual
11	St. Bernard Bowl	IHCN Breach	Failure MRGO/GIWW gate	Individual

12	St. Bernard Bowl	GIWW Breach	Failure MRGO/GIWW gate	Individual
13	St. Bernard Bowl	Lake Borgne breach	Storm surge	Individual
14	Metro Bowl, East Bowl	Lake Pontchartrain Breach	Storm surge	Multiple
15	St. Bernard Bowl, East Bowl	Lake Borgne breach	Storm surge	Multiple
16	Metro Bowl, East Bowl, St. Bernard Bowl	IHNC Breach and GIWW Breach	Failure IHNC & MRCO/GIWW gate	Multiple

3 Proposed research on flood risk

A first risk to life analysis for the post-Katrina situation for the New Orleans Metro Bowl is available [Miller, 2011]. A full-integrated risk analysis for the greater New Orleans is recommended. In the scope of this project, we recommend to examine a risk to life analysis for the following three dike rings, viz. New Orleans Metro Bowl, New Orleans East en St. Bernard Bowl.

We propose the following steps:

1. Analysing the systems' reliability;
2. Flood simulations;
3. Determining the consequences;
4. Quantifying risk.

- Flood simulations for post-Katrina situation for St. Bernard Bowl and Orleans East Bowl;
- Take several hydraulic load levels (so as well more extreme scenarios) into account;
    - We recommend three hydraulic load level (under normative scenario, design water level and above normative scenario 'worstcase');
        - 1/50 per year
        - 1/100 per year
        - 1/1000 per year
    - For less severe hydraulic load conditions make 'overtopping' simulations (in case overtopping does not directly have a breach to result);